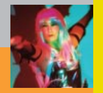
BEYOND PRODUCTIVITY

Information Technology and Creative Practices



INFORMATION TECHNOLOGY AND CREATIVE PRACTICES

At the beginning of the 21st century, an exciting new field is emerging from the powerful alliance of information technology and the arts and design—information technology and creative practices, or ITCP. It is beginning to forge new connections, challenge assumptions, and demand new ways of conceptualizing and changing the world around us. ■ Furthering this alliance, *Beyond Productivity: Information Technology, Innovation, and Creativity* recognizes the broad cultural, economic, and social value of ITCP, far beyond productivity and innovation as they are usually understood and measured. This report, published by the Computer Science and Telecommunications Board of the National Academies and commissioned by the Rockefeller Foundation, explores revolutionary developments that have already taken shape at the intersection of information technology and the arts and design. It examines how ITCP forces a reshaping of traditional thinking about both art and design and information technology. The report makes recommendations for how colleges and universities, government, industry, and nonprofit organizations can foster ITCP in ways that have yet to be explored.

IMAGE COURTESY OF GEHRY TECHNOLOGIES, LLC.

ARCHITECTURE BEYOND THE DRAWING BOARD

COMPUTER-AIDED DESIGN (CAD) AND COMPUTER-AIDED MANUFACTURING WERE INTEGRAL IN THE CONSTRUCTION OF FRANK O. GEHRY'S WALT DISNEY CONCERT HALL IN LOS ANGELES. CAD BECAME INCREASINGLY IMPORTANT TO THE PROJECT OVER ITS 16 YEARS BECAUSE OF THE BUILDING'S COMPLEXITY. THE STRUCTURE CONTAINS NEARLY 11,000 PIECES OF STEEL, ALMOST ALL OF THEM DIFFERENT FROM EACH OTHER. THREE-DIMENSIONAL WIRE FRAME MODELS WERE GENERATED, AND DETAILED DATA ABOUT THE CUSTOM STEEL GIRDERS WAS INTEGRATED INTO THIS MODEL. IN ADDITION, A FOUR-DIMENSIONAL ANIMATED MODEL SHOWING THE BUILDING'S STRUCTURE LINKED TO THE CONSTRUCTION SCHEDULE HELPED CONTRACTORS UNDERSTAND WHAT WAS NEEDED AT EACH STAGE OF CONSTRUCTION. THE PROJECT ALSO INSPIRED SOFTWARE MAKERS AND PROJECT MANAGERS TO ENVISION A PLATFORM FOR ARCHITECTURAL PROJECT MANAGEMENT, WORKING ACROSS THE INTERNET, THAT CENTRALIZED DATA ABOUT THE BUILDING'S DESIGN AND STRUCTURAL REQUIREMENTS AND ALLOWED FOR INSTANT COMMUNICATION AMONG PARTICIPANTS IN THE PROJECT.

THE WHOS, WHATS, AND WHERES OF ITCP

Although there are those rare individuals who are fluent in multiple disciplines, much of the work in ITCP is accomplished by cross-disciplinary collaborative groups. ■ Collaborations between information technologists and artists and designers present myriad challenges. For some, the most difficult obstacle to overcome is an old cultural bias—the long-standing misperceptions and lack of understanding between artists and designers and scientists and technologists. Differences in the type and amount of funding available to scientists and technologists as compared with artists and designers, in terminology, and in different professional recognition systems, present additional challenges. ■ By its very nature, ITCP often does not fall gracefully into established sectors such as academia, cultural institutions, industry, or government. Rather, it requires the exploration and development of creative environments in multiple or hybrid contexts. The diversity of venues for ITCP work—such as university media labs, industrial research labs, performance studios, museums, and art galleries—contributes to the inventiveness of the work. Different venues present different structures, funding opportunities, and access to technologies.

In capturing the synergies among science, culture, technology, and economics, *Beyond Productivity* reveals new pathways for creative practice and challenges funders to expand their current approaches to encompass the emergence of new and cutting-edge work.

—*JOAN SHIGEKAWA, ASSOCIATE DIRECTOR, THE ROCKEFELLER FOUNDATION*

itcp

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—*WM. A. WULF, PRESIDENT, NATIONAL ACADEMY OF ENGINEERING*

WHAT COMPUTER SCIENCE CAN DO FOR ART AND DESIGN

Computer and communications hardware and software tools for creating, editing, and distributing images, audio, and text continue to develop at a rapid pace—but not fast enough to truly advance ITCP. IT deals with information in its purest form—bits—and IT tools promise infinite flexibility in their ability to mediate and help construct new art forms. However, these tools tend to incorporate many restrictive assumptions about how best to facilitate art and design. Off-the-shelf hardware and software tools may have limited flexibility, so artists and designers may decide to create their own digital media applications—if they have extensive technical knowledge, time, and money. ■ Increasingly flexible technologies feature "plug-ins," which help to customize off-the-shelf design applications. New software can be developed that would allow users to create their own tools—the equivalent of a "meta-toolkit." Developing more nuanced user interfaces, functions, and conceptual frameworks for software tools is a research challenge. In the hardware arena, more versatile sensors and actuators—as well as advanced tools to simplify their use—are needed. ■ In lieu of creating each musical note or brushstroke by hand, an artist or designer may want to use a mechanism for creating unpredicted, random, and potentially interesting output. Although programmers can readily set up such generative systems, tools are needed to encapsulate them for greater use by non-experts. Similarly, although software that coordinates multiple computers has been among the most difficult of programs to write, new tools for distributed control could provide simplified protocols.

IMAGE COURTESY OF KARIM RASHID INC.

MASS PRODUCTION OF UNIQUE OBJECTS

INFORMATION TECHNOLOGY HAS MADE IT POSSIBLE FOR INDUSTRIAL DESIGNERS LIKE KARIM RASHID TO WORK CREATIVELY ON A NEW LEVEL—THE LEVEL OF THE MANUFACTURING PROCESS ITSELF. THE MACHINE THAT PRODUCED RASHID'S TEA KETTLES, EACH ONE SLIGHTLY DIFFERENT FROM THE OTHER, IS CONTROLLED BY SOFTWARE THAT GENERATES RANDOM WIDTH, CIRCUMFERENCE, AND HEIGHT MEASUREMENTS WITHIN A RANGE. THIS PROCESS INEXPENSIVELY CREATES THOUSANDS OF UNIQUE OBJECTS AS OPPOSED TO THOUSANDS OF COPIES OF ONE OBJECT, ALLOWING RASHID TO MAKE HIS DESIGNS AVAILABLE TO THE CONSUMER MARKET. THE RESULT COMBINES THE UNIQUENESS OF HANDCRAFT WITH THE SCALE OF INDUSTRIAL PRODUCTION.

WHAT IS "REAL" INTERACTION?

TELEROBOTICS, THE USE OF COMMUNICATIONS TECHNOLOGIES AND ROBOTS TO FACILITATE LIVE INTERACTION WITH REAL PHYSICAL ENVIRONMENTS FROM A DISTANCE, FURNISHES NEW INSIGHT INTO CLASSICAL QUESTIONS ABOUT THE NATURE AND POSSIBILITY OF KNOWLEDGE AND EXPERIENCE. KEN GOLDBERG'S TELEGARDEN IS A TELEROBOTIC ART INSTALLATION ON THE INTERNET WHERE REMOTE USERS DIRECT A ROBOT, WHICH IS HOUSED AT ARS ELECTRONICA IN LINZ, AUSTRIA, TO PLANT AND WATER SEEDS IN A REAL GARDEN. FEEDBACK FROM TELEGARDEN'S VISITORS PROVIDES GOLDBERG AND HIS COLLEAGUES WITH INFORMATION ABOUT HOW PERCEPTION, KNOWLEDGE, AND FREE WILL ARE BEING DEFINED IN INTERACTION WITH THE ROBOT. FOR EXAMPLE, THEY HAVE FOUND THAT SOME VISITORS ARE SKEPTICAL OF THE EXPERIENCE, WONDERING WHETHER THE TELEGARDEN IS REAL IN THE PHYSICAL SENSE, OR IS INSTEAD A DIGITAL IMITATION OF A GARDEN.

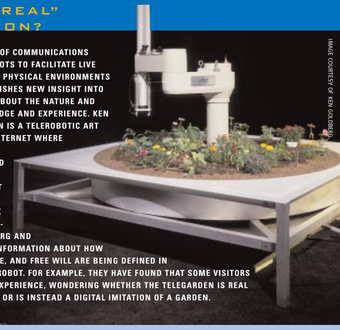

IMAGE COURTESY OF KEN GOLDBERG

WHAT ART AND DESIGN CAN DO FOR COMPUTER SCIENCE

Just as advances made by IT researchers can help to stimulate new forms of art and design practice, so questions raised by artists and designers can provide new ways of thinking about IT. ITCP is broadening the view of computer science by increasing the examination of the larger social context, meaning, and purpose of IT. Researchers and practitioners in the arts and design can be thought of as pioneering information scientists—finding and forging new connections of understanding between disparate ideas and groups, seeking new ways of seeing and new modes of conveying information. ■ The impact of the arts and design on computer science follows a transdisciplinary model: rather than simply creating new areas of inquiry where IT and the arts overlap, transdisciplinary research imagines entirely new possibilities for what disciplines can do. For example, "mixed reality" entails a fusion of industrial design and the human-computer interface that breaks the boundary of a traditional user interface (based on buttons and switches, for instance) and harnesses intuitive human responses to everyday physical objects as a new way of processing complex information. ■ "Narrative intelligence" uses narrative and literary theory to develop artificial intelligence. Conceptualizing creative thought in this way compels researchers to produce complex models of the human tendency to understand the world in terms of storytelling. In addition, a deeper understanding of narrative structure in words and images drives the development of more sophisticated computer games. This desire for greater complexity and multiplayer interaction in the virtual world of the computer game raises increasingly challenging technical questions that might not have been posed otherwise.

Beyond Productivity is required reading for policy makers in the arts, humanities, and information technology. The report identifies key concepts that can enhance the impact of federal funding and continued collaboration, and spur a national dialogue and a call to action to support this vital work.

—*ROBERT S. MARTIN, DIRECTOR INSTITUTE OF MUSEUM AND LIBRARY SERVICE*

WHY INVEST IN ITCP?

ITCP affects society far beyond the technical and cultural elites. Creativity is regarded widely as a product of great social and cultural value in itself, but is also prized as an enabler of technological innovation. New inventions can result in commercially successful products as well as enhancements to the quality of life. Creativity can also forge new alliances between disparate fields and enterprises, fostering entrepreneurial activity and encouraging investment. ▪ In a similar way, creativity can boost the perceived value of a community by deepening its cultural heritage—nations and cities take immense pride in works of art, cultural figures, and scholarly institutions that they can call their own. Creative practices also form the foundation of the so-called creative industries. Cultural development brings vitality to both local and global communities, encouraging active participation and investment. Investing further in these fields could yield continued reward: broad intellectual and cultural enrichment, billion-dollar industries, and enhanced global influence.

Cultural institutions will continue to be challenged by the needs and expectations of new audiences seemingly born with a computer mouse in their hand. Beyond Productivity is a book we should all pay attention to as we seek fresh ways to sustain cultural enterprise and create new strategies for economic development.

—DANIEL T. KEEGAN, OSHMAN EXECUTIVE DIRECTOR, SAN JOSE MUSEUM OF ART

ABOUT CSTB

The Computer Science and Telecommunications Board is the program unit of the National Research Council that provides authoritative, independent advice to the government on national science and policy issues related to computing and communications systems.

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Advisers to the Nation on Science, Engineering, and Medicine

SEEING, HEARING, AND FEELING THE FLOW OF INFORMATION

A PHYSICAL REPRESENTATION OF UBIQUITOUS COMPUTING, NATALIE JEREMIJENKO'S DANGLING STRING EXHIBIT IS AN 8-FOOT-LONG PIECE OF PLASTIC STRING SUSPENDED FROM A SMALL MOTOR IN THE CEILING. THE MOTOR IS CONNECTED TO AN ETHERNET CABLE. TRAFFIC OVER THE NETWORK CAUSES THE STRING TO WHIRL MADLY (DURING TIMES OF HIGH TRAFFIC) OR TWITCH MILDLY (IN RESPONSE TO LOW TRAFFIC). COMPUTER USERS ARE ACCUSTOMED TO THINKING OF A SCREEN AS THE ONLY TYPE OF DISPLAY THAT IS CAPABLE OF CONVEYING DATA, BUT THE DANGLING STRING AND OTHER EXAMPLES OF "CALM TECHNOLOGY" OFFER AN IMMEDIATE YET UNOBTRUSIVE PHYSICAL DISPLAY OF COMPLEX INFORMATION.

IMAGE COURTESY OF ARTHUR FERRANTINI

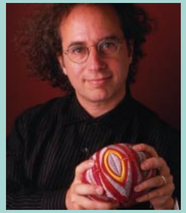
THE ROLE OF HIGHER EDUCATION AND ACADEMIA

The success of ITCP depends immensely on its strength in colleges, universities, and schools of art and design. As sources of knowledge and training, these institutions facilitate the acquisition of new skills and insights. In addition to teaching the basics, they provide a place to study how the new differs from—but can build on—the old. And as a ready source of talented labor and other resources, they attract the involvement of external ITCP practitioners. ▪ Several different approaches can be taken to create an academic environment that facilitates ITCP. Pioneering exploration of ITCP has taken place in stand-alone facilities dedicated specifically to transdisciplinary work, such as the Media Lab at the Massachusetts Institute of Technology. Other universities have formed special interdepartmental centers and curricula that feature ITCP. Most architecture and design schools have supplemented drawing boards with CAD tools, and a number of art departments and schools have transformed their curricula altogether along IT-based lines. Other emerging support mechanisms include informal workshops on specific ITCP-related topics and service units such as ITCP-oriented libraries. Several film schools, meanwhile, have shifted their emphasis from traditional to digital production and distribution technologies. ▪ These are important beginnings, but ITCP will become truly established in academia only when it is adopted in earnest by the mainstream departments and disciplines—notably those of computer science, art, and design—because it is there that the basis for later specialization in ITCP is provided. ▪ In general, arts and design departments at colleges and universities have embraced ITCP more than have computer science departments. By contrast, computer science faculties have generally been much less receptive to ITCP, reflecting an attitude that art- and design-related work is peripheral—not "real computer science." This perception is reinforced by the rigid incentive structure in computer science departments: the accepted criteria for tenure involve prolific publication of research in top technical journals and endorsements by experts in established technical fields. ▪ Several steps can be taken to overcome such resistance in computer science departments and more traditional art and design departments. Administrators should make it easier for people from different disciplines to work together on ITCP. For example, they can provide modest grants, facility space, and other resources to informal faculty or graduate-student groups, some of which may later blossom—and then be supported at increasing levels of funding. And effective mentoring can help these innovators publish in traditional journals.

BROADER PUBLIC POLICY AND INSTITUTIONAL ISSUES

National and global factors—beyond the control of individual practitioners and their institutions—influence the new field of ITCP. Among these are digital copyright, digital archiving and preservation, and professional recognition structures. More research and inquiry (among other things) are needed in order to fully understand and overcome these challenges. ▪ Digital content and networks have not been well served by intellectual-property laws, which were crafted mostly for a world of physical artifacts, not electronic bits. Efforts to revise intellectual property laws should include consideration of how ITCP can be supported. Archiving ITCP work also presents a challenge. In theory, digital information may easily be archived because it is perfectly reproducible and therefore potentially eternal, but in practice this is not the case. Digital content can become difficult to read in less than a decade as formats and systems for digital content evolve. A number of digital art archiving efforts are underway; their aim is to establish guidelines by which museums, galleries, and artists may preserve ITCP work in a way that promotes stewardship, not mere storage. ▪ In an interdisciplinary context, the recognition structures of any one field do not necessarily apply easily to work resulting from collaborations between several established fields. New mechanisms, such as dedicated journals, curatorial Web sites, and awards and prizes, are needed for evaluating and rewarding ITCP practitioners.

MAKING IMPROVISATIONAL MUSIC MORE TANGIBLE



"MUSIC SHAPERS", CREATED BY TOD MACHOVER OF THE MIT MEDIA LAB, ARE HANDHELD INSTRUMENTS THAT ENCOURAGE CHILDREN TO EXPLORE MUSICAL IMPROVISATION. THE BRIGHTLY COLORED MUSIC SHAPERS ARE SOFT, SQUEEZABLE MUSICAL INSTRUMENTS THAT USE CAPACITIVE SENSING AND ELECTRICALLY CONDUCTIVE EMBROIDERY TO DETECT AND RESPOND TO THE USER'S MOVEMENTS. CHILDREN IMPROVISE BY SQUEEZING AND MOVING THE MUSIC SHAPER TO MANIPULATE THE TIMBRE, DENSITY, AND STRUCTURE OF THE MUSIC. THIS LEVEL OF CONTROL OVER IMPROVISATION WOULD NOT OTHERWISE BE A POSSIBILITY FOR PEOPLE WHO HAVE NOT HAD YEARS OF TRAINING ON A TRADITIONAL MUSICAL INSTRUMENT.

THE ROLE OF GOVERNMENT, NONPROFIT ORGANIZATIONS, AND INDUSTRY

Progress in any activity, new or old, depends on sufficient funding. However, emerging fields like ITCP must contend with established and often-unsuitable categorizations. The hybrid nature of ITCP means that its funding can come from government, foundations and other grant makers, industry, or some combination thereof. Although some notable experiments involving federal support of ITCP-like projects do exist in the United States, most federal funding for computer science research typically goes to work that fits within specific government missions. Federal appropriations to cultural agencies and organizations, when considered in aggregate, are comparable in magnitude to federal support for computer science research, but only a small fraction of cultural funds are earmarked for the equivalent of research. Exploratory work in the arts and design is supported primarily through private philanthropy from individuals, foundations, and corporations. However, these donors tend to give to established institutions with name-recognition or commercially viable projects such as movies and computer games. ▪ A major challenge for funders, therefore, is to foster collaborations that open up new areas of ITCP instead of merely supporting work by specialists in established areas of art and design and IT. This can happen in several ways: more funds can be allocated to true ITCP work; proposal review processes can be restructured to encourage higher-risk, longer-term ITCP research; and more leeway can be given to program managers to learn about new fields and new kinds of grantees. A new grant-making category should be developed for tool building, emphasizing the creation of tools and instruments that are extensible and provide support for improvisation. ▪ Additionally, funders could underwrite research on the formation of creative clusters, which have traditionally tended to concentrate geographically (Silicon Valley and New York City as centers of IT and art and design innovation, respectively, are examples). By its very nature, ITCP can take this model a step further, by electronically connecting scattered islands of creative activity, leading to the formation of multinational ITCP alliances and organizations. Such alliances not only give developing nations and individual practitioners wider access to global resources and markets, but also bring together the contributions of unique workforces that might not otherwise be aware of each other. ▪ Large commercial entities have combined centralized research, development, and marketing strategies to produce major ITCP successes. The popularity of computer-animated movies and computer games provides evidence. Smaller entities, including architectural-design, product-design, graphic-design, and music- and video-production houses, have opened up exciting new areas through their extensive use of IT tools and media. Commercial enterprises should continue to develop new tools, products, and services related to ITCP, and they should actively participate in the formation of creative clusters.

IMAGES COURTESY OF MIT MEDIA LABORATORY (WEBB CHAPPELL AND JASON CLARK PHOTOGRAPHY)

Beyond Productivity is a welcome addition to the literature acknowledging the extraordinary interdependence and importance of art, science, and the creative process in today's world.

— GEORGE CAMPBELL JR., PRESIDENT, THE COOPER UNION FOR THE ADVANCEMENT OF SCIENCE AND ART

IMAGE COURTESY OF CURTIS BAHN.

INTERACTIVE MUSIC THROUGH MOVEMENT

"PIKAPIKA," A CHARACTER BASED ON JAPANESE POP ANIMATION AND COMICS, IS A COLLABORATION BETWEEN DANCER AND ETHNOMUSICOLOGIST TOMIE HAHN AND INSTRUMENT BUILDER CURTIS BAHN. AS PIKAPIKA, HAHN WEARS A SENSOR DEVELOPED BY BAHN THAT DETECTS HER DANCE MOVEMENTS (BASED ON *BUNRAKU*, JAPANESE PUPPET THEATRE) AND SENDS GESTURAL AND SPATIAL INFORMATION TO AN INTERACTIVE COMPUTER MUSIC SYSTEM. THE SYSTEM'S ALGORITHM PRODUCES SOUNDS THAT ARE BROADCAST FROM WIRELESS SPEAKERS PLACED ON HAHN'S BODY, AND ARE REPRESENTED AS AN ABSTRACT MOVING VISUAL DISPLAY ON A SCREEN BEHIND HER. THE RESULTING SONIC PUNCTUATION OF MOVEMENT CREATES AN AUDIOVISUAL "MASK" AROUND THE DANCER THAT CONVEYS THE PERSONALITY AND STORY OF THE CHARACTER PIKAPIKA.

ABOUT THIS STUDY

This brochure is derived from *Beyond Productivity: Information Technology, Innovation, and Creativity*, a report that examines the dynamic intersection of information technology and the world of the arts and design. *Beyond Productivity* was produced by the Committee on Information Technology and Creativity under the auspices of the Computer Science and Telecommunications Board of the National Academies. The diverse study committee included academic and industry experts in information ITCP

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